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A Biological Assessment of Sites on Beaver Creek: Fergus County, Montana July 23-24, 2003

By W. Bollman
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A BIOLOGICAL ASSESSMENT OF SITES ON BEAVER CREEK: FERGUS COUNTY, MONTANA

July 23 - 24, 2003

A report to

The Montana Department of Environmental Quality
Planning, Prevention and Assistance Division
Helena, Montana
Rebecca Ridenour, Project Officer

by

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected on July 23 - 24, 2003 from 3 sites on Beaver Creek, a tributary of the Musselshell River in Fergus County, Montana. These sites lie within the Northwestern Great Plains ecoregion (Woods et al. 1999), although the uppermost site in the study, BEVR 1, may lie in the Montana Valley and Foothill Prairie (MVFP) ecoregion. Beaver Creek is within the Judith River watershed.

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits.

Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples.

In this report, 3 assessment methods are used: first, taxonomic data is translated into 2 bioassessment indices, and metric scores in each index are summed to derive impairment classifications and use support designations. Second, a narrative interpretation, based on the author's professional judgment is given. Metric performance and taxonomic data are both applied to this analysis. Third, the model of Barbour and Stribling (1991) is applied to bioassessment and habitat assessment scores.

While the interdependence of these methods is obvious, since the same data are used for all, some degree of independence is maintained throughout the analysis. Narrative interpretations are given without regard to the bioassessment index result and without reference to habitat assessment. Since indices are summations, they can often mask evidence of impairment; the narratives attempt to expose the potential shortcomings of the indices. Similarly, graphing the association between habitat assessment scores and bioassessment scores using the model of Barbour and Stribling can provide clues to offer support or possible refutation of the conclusions of the narrative analysis.

METHODS

Samples were collected on July 23 - 24, 2003 by Montana Department of Environmental Quality (Montana DEQ) personnel. Sample designations and site locations are indicated in Table 1 and on Figure 1. The site selection and sampling method employed were those recommended in the Montana DEQ Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses.

In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

Table 1. Sample designations and locations. Sites are listed in upstream-to-downstream order. Beaver Creek, July 23 - 24, 2003.

Site ID	Station ID	Activity ID	Location Description	Collection Date	Latitude	Longitude
BEVR 1	M22BEVRC01	03-L472-M	Beaver Creek @ Regli	7/23/03	46°-56'-10.68"	109°-31'-8.76"
BEVR 2	M22BEVRC02	03-L471-M	Beaver Creek @ Smith Ranch	7/23/03	46°-58'-54.12"	109°-33'-26.64"
BEVR 4	M22BEVRC04	03-L487-M	Beaver Creek near mouth	7/24/03	47°-4'-46.194"	109°-35'-56.04"

Two bioassessment indices were employed in evaluating the data. First, the metric battery recommended in the Montana DEQ standard operating procedures (Bukantis 1998) was used. Metrics and scoring criteria for this method are given in Table 2. These metrics should be considered provisional, since correlative relationships between them and meaningful measures of habitat condition and water quality have not been evaluated. Assurance of the validity of associations between meaningful habitat measures and biotic metrics is particularly compelling in the Plains ecoregion, since impairment of the biotic health of streams in this region is generally the result of non-point sources of water quality degradation and habitat disturbance. Agricultural activities, including cattle grazing and flow alteration, are predominant causes of disturbance. The benthic assemblages of the Plains ecoregions and the performance of these bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. Thus, conclusions concerning bioassessment based upon these metrics must be regarded as tentative. To facilitate scoring, metric values were transformed into a non-dimensional scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event.

Recently, multimetric bioassessment indices using aquatic invertebrates were developed by Bramblett et al. (2002) for streams of the Plains ecoregions of Montana. These indices were evaluated for responsiveness to anthropogenic disturbances, lack of responsiveness to natural factors, and temporal stability. Although the indices probably need further refinement and have not yet been accepted for standard bioassessment use by the State, metric values, scores, and assessments using the appropriate index are given here in Table 5. To allow for comparison with the Montana DEQ standard procedure, Figure 1 pairs scores from each method with each Plains stream site.

Figure 1. Approximate sampling locations. Beaver Creek, July 2003.

For both bioassessment methods, total scores were expressed as the percent of the maximum possible score and these were converted into use support classifications. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table 2. Provisional metrics and scoring criteria for the Montana Plains ecoregions. (Bukantis, 1998).

METRICS	SCORES			
	3	2	1	0
Taxa richness	>24	24 - 18	18 – 12	<12
EPT richness	>8	8 – 6	5 – 3	<3
Biotic Index	<5	5 – 6	6 – 7	>7
% Dominant taxon	<30	30 – 45	45 – 60	>60
% Collectors	<60	60 - 80	80 – 95	>95
% EPT	>50	50 - 30	30 - 10	<10
Shannon H (log2)	>3.0	3.0 – 2.4	2.4 – 1.8	<1.8
% Scrapers + shredders	>30	30 – 15	15 – 3	<3
# Predator taxa	>5	4 - 5	3 - 4	<3
% Multivoltine	<40	40 – 60	60 – 80	>80

Table3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

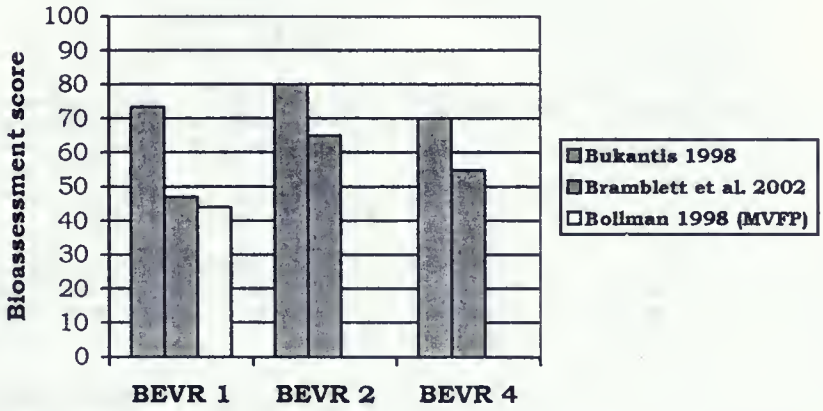
RESULTS

Bioassessment

Table 4 itemizes each metric in the Montana DEQ battery (Bukantis 1998) and shows individual metric scores for each site. Tables 5a and 5b similarly show the metrics and scores for the revised Plains battery (Bramblett et al. 2002). In addition, a score was generated for the uppermost site using the revised index for the MVFP ecoregion (Bollman 1998a). Table 6 itemizes metrics and scores for this index. Figure 2 compares total bioassessment scores for each of the 3 Beaver Creek sites and also compares the results of the 3 bioassessment methods.

The methods gave differing results when applied to these data; although the biotic integrity of the 3 sites were ranked in the same order regardless of the index used, the uppermost site (BEVR 1) was classified differently by the 3 methods. When the Montana DEQ battery (Bukantis 1998) was used to calculate scores, all 3 sites appeared slightly impaired. The uppermost (BEVR 1) and lowermost (BEVR 4) sites partly supported designated uses, and the middle site (BEVR 2) fully supported uses. When the revised Plains index (Bramblett et al. 2002) or the revised MVFP index was used, the middle (BEVR 2) site was moderately impaired while the uppermost (BEVR 1) and lowermost (BEVR 4) sites were slightly impaired. All 3 sites were partially supportive of designated uses. In each case, the Montana DEQ battery rendered higher bioassessment scores than the revised Plains or MVFP indices.

Figure 2. Comparison of total bioassessment scores (reported as percent of maximum score). The Montana Plains ecoregions reference (Bukantis 1998) was used to calculate scores represented by gray bars, and a revised Plains battery (Bramblett et al. 2002) was used to calculate scores represented by brown bars. The yellow bar represents the score generated for the uppermost site (BEVR 1) when the revised Montana Valley and Foothill Prairie index (Bollman 1998) was used. Beaver Creek, July 23 - 24, 2003.



Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature and expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be

useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

Table 4. Bioassessment metrics and scores for 3 sites on Beaver Creek. Site locations are given in Table 1. Montana Plains ecoregions reference (Bukantis 1998).

	SITES		
METRIC VALUES	**BEVR 1**	**BEVR 2**	**BEVR 4**
Taxa richness	25	30	25
EPT richness	4	11	7
Biotic Index	4.26	6.28	5.43
% dominant taxon	21.43	27.54	44.41
% collectors	52.04	77.97	65.46
% EPT	8.99	56.80	58.22
Shannon diversity	2.12	2.90	1.95
% Scrapers + shredders	34.35	11.01	22.04
# Predator taxa	9	10	5
% Multivoltine	58.55	14.97	44.74
METRIC SCORES			
Taxa richness	3	3	3
EPT richness	1	3	2
Biotic Index	3	1	2
% dominant taxon	3	3	2
% collectors	3	2	2
% EPT	0	3	3
Shannon diversity	1	2	1
% Shredders + scrapers	3	1	2
# Predator taxa	3	3	2
% Multivoltine	2	3	2
TOTAL SCORE	22	24	21
PERCENT OF MAXIMUM	**73.33**	**80.00**	**70.00**
IMPAIRMENT CLASSIFICATION[1]	**SLI**	**SLI**	**SLI**
USE SUPPORT[1]	**PART**	**FULL**	**PART**

[1] Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. Use support classifications: (FULL) fully supports designated uses, (PART) partially supports designated uses, (NON) non-supportive of designated uses. See Table 3b for impairment classification criteria and Table 3a for use support criteria.

The benthic fauna collected at the uppermost site on Beaver Creek (BEVR 1) resembled that of a foothill stream; this supports use of the revised MVFP index (Bollman 1998a). Perlodid and nemourid stoneflies and limnephilid caddisflies would be expected in the foothills, but are uncharacteristic of the Plains. It is interesting to note the similarity of scores and impairment classes generated by the revised Plains index (47% of maximum, moderate impairment) and the revised MVFP index (44% of maximum, moderate impairment). The sample collected at the site yielded only 2 mayfly taxa, and the biotic index value (4.26) was somewhat higher than expected for a foothill stream. Some impairment of water quality, such as by mild nutrient enrichment, is suggested by these findings.

Table 5a. Bioassessment metrics and scores for the middle site on Beaver Creek. Site location is given in Table 1. The revised Montana Plains bioassessment index (Bramblett et al. 2002) for pool sites was used.

	SITE
	BEVR 2
METRIC VALUES	
Ephemeroptera richness	1
Trichoptera richness	3
% EPT	56.8
% non-insect	11.01
Filterer richness	2
Univoltine richness	19
% supertolerant	13.04
METRIC SCORES	
Ephemeroptera richness	16.67
Trichoptera richness	75.00
% EPT	100.00
% non-insect	86.19
Filterer richness	50.00
Univoltine richness	100.00
% supertolerant	27.33
TOTAL SCORE (% of maximum)	**65.03**
IMPAIRMENT CLASSIFICATION[1]	**SLI**
USE SUPPORT[1]	**PART**

[1] Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. Use support classifications: (FULL) fully supports designated uses, (PART) partially supports designated uses, (NON) non-supportive of designated uses. See Table 3b for impairment classification criteria and Table 3a for use support criteria. These criteria were applied even though classifications and criteria have not been established for this index.

Five caddisfly taxa and 9 "clinger" taxa appeared in the sample. Some stony substrate habitat, uncontaminated by sediment deposition appears to have been available. Overall taxa richness was lower than expected for a foothill stream; other types of instream habitats may have been generally limited here. Stonefly taxa richness may be associated with reach-scale habitat features. Since at least 4 stonefly taxa were supported at this site, it seems likely that stable streambanks, natural channel morphology, and intact riparian zones characterized the reach. Five semivoltine taxa were collected; it seems unlikely that dewatering or other catastrophes were among recent events here. The functional composition included all expected elements, but filter-feeders, especially the caddisfly *Hydropsyche* sp. and the blackfly *Simulium* sp. were abundant. This finding is consistent with mild nutrient enrichment. Shredders were well-represented, suggesting that riparian inputs of large organic material were ample, and hydrologic conditions favored retention of such material.

A single mayfly taxon (*Tricorythodes* sp.) was collected at the middle site on Beaver Creek (BEVR 2), and the biotic index value was higher than expected for a Plains stream. Warm water temperatures and nutrient enrichment may be limiting the fauna at this site. More than

Table 5b. Bioassessment metrics and scores for 2 sites on Beaver Creek. Site locations are given in Table 1. The revised Montana Plains bioassessment index (Bramblett et al. 2002) for riffle sites was used.

	SITES	
	BEVR 1	**BEVR 4**
METRIC VALUES		
EPT richness	4	7
Percent EPT	8.99	58.22
Percent oligochaetes and leeches	1.36	0.00
Percent 2 dominants	34.69	61.51
Filterer richness	3	5
Percent intolerant	19.73	1.64
Univoltine richness	10	6
Percent clingers	48.41	83.22
Swimmer richness	2	1
METRIC SCORES		
EPT richness	36.36	63.64
Percent EPT	11.15	72.23
Percent oligochaetes and leeches	86.12	100.00
Percent 2 dominants	55.47	21.04
Filterer richness	50.00	83.33
Percent intolerant	38.16	3.17
Univoltine richness	58.82	35.29
Percent clingers	58.12	99.90
Swimmer richness	28.57	14.29
TOTAL SCORES (% of maximum)	**46.98**	**54.77**
IMPAIRMENT CLASSIFICATION[1]	**MOD**	**SLI**
USE SUPPORT[1]	**PART**	**PART**

[1] Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. Use support classifications: (FULL) fully supports designated uses, (PART) partially supports designated uses, (NON) non-supportive of designated uses. See Table 3b for impairment classification criteria and Table 3a for use support criteria. These criteria were applied even though classifications and criteria have not been established for this index.

60% of animals taken in the sample were midges or non-insects. Five hemoglobin-bearing taxa, including immature tubificid worms and the midges *Chironomus* sp., *Cryptochironomus* sp., and *Dicrotendipes* sp. were present, suggesting hypoxic substrates. Such conditions are associated with nutrients and warm water.

The presence of 7 "clinger" taxa suggests that some clean stony substrate habitats were available at this site. Macrophytes may have added complexity to instream habitats, since plant-associated animals (e.g. *Hydroptila* sp., *Paratanytarsus* sp., *Cricotopus (Cricotopus)* spp., *Dubiraphia* sp.) were common. Habitats were apparently diverse enough to support at least 25 taxa. The semivoltine fauna was represented by only 2 taxa; periodic dewatering, scouring sediment pulses, thermal stress, or other events that would limit long life cycles cannot be ruled out here. Gatherers dominated the functional mix; this finding is consistent with nutrient enrichment.

Only 2 mayfly taxa were represented in the sample collected near the mouth of Beaver Creek (BEVR 4). The biotic index value was somewhat elevated compared to expectations for a Plains stream. Nutrient enrichment and warm water temperatures may be indicated by these findings.

Nine "clinger" taxa and 5 caddisfly taxa were present in the sampled assemblage, suggesting stony substrates free from sediment deposition were available. Animals associated with aquatic plants, such as midges in the Cricotopus Trifascia Group, and *Hydroptila* sp., were common; macrophytes may have contributed to instream habitat complexity. Two semivoltine taxa were present. Periodic dewatering or thermal stress cannot be ruled out at this site. The functional components were dominated by filter-feeders, implying abundant fine organic material in suspension.

Table 6. Bioassessments metrics and scoresfor the uppermost site on Beaver Creek. Site location is given in Table 1. The revised index for the MVFP ecoregion (Bollman 1998) was used.

METRICS	BEVR 1
	METRIC VALUES
Ephemeroptera richness	2
Plecoptera richness	4
Trichoptera richness	5
Number of sensitive taxa	0
% filterers	35.37
% tolerant taxa	13.27
	METRIC SCORES
Ephemeroptera richness	1
Plecoptera richness	3
Trichoptera richness	3
Number of sensitive taxa	0
% filterers	0
% tolerant taxa	1
TOTAL SCORE (max.=18)	8
PERCENT OF MAX.	**44**
Impairment classification*	**MOD**
USE SUPPORT †	**PART**

* Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.† Use support designations: See Table 3a.

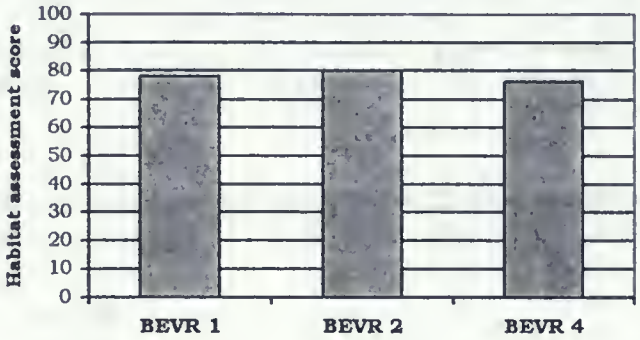
CONCLUSIONS

- Evidence of nutrient enrichment and/or warm water temperatures was suggested by the faunae collected at all 3 Beaver Creek sites. Dewatering or other catastrophes could not be ruled out at the middle (BEVR 2) and lowermost (BEVR 4) sites.
- Instream habitats at the lower sites (BEVR 2 and BEVR 4) probably consisted of soft substrates, limited areas of clean stones, and macrophytes.

Habitat assessment[1]

Figure 3 graphically compares total habitat assessment scores recorded for the 3 sites in this study. Tables 7a and 7b show the habitat parameters evaluated, parameter scores and overall habitat evaluations for the sites studied.

Figure 3. Total habitat assessment scores for Beaver Creek sites. July 23 - 24, 2003.



Overall habitat conditions at the upper (BEVR 1) and middle (BEVR 2) sampled sites on Beaver Creek were judged optimal. The lowermost site (BEVR 4) scored sub-optimally for overall habitat conditions.

The uppermost site on Beaver Creek (BEVR 1) received optimal and suboptimal ratings for all instream parameters. Bank stability and vegetative protection was judged marginal on the right side of the channel, and the riparian zone width was marginal or poor. At the middle site (BEVR 2), all instream and streambank parameters were rated optimal or sub-optimal. The riparian zone was abbreviated on the right side of the channel. Marginal flow conditions were reported at the lowermost site (BEVR 4), but all other parameters were judged optimal or sub-optimal.

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[1] In this report, habitat assessment scores are calculated to be consistent with Montana DEQ habitat assessments. That is, scores for those parameters referring to left and right bank conditions are averaged and not summed. Thus, severe degradation of streambanks, bank vegetative protection, and riparian zone widths that occur on only one side of a channel may not be clearly reflected in total scores. Summing these scores, and allowing the parameters to be weighted in accordance with summed scores, may better reflect the influence of streambank and riparian zone condition on benthic assemblages.

Table 7a. Stream and riparian habitat assessment. This Beaver Creek site was assessed based upon criteria developed by Montana DEQ for streams with glide/pool prevalence. July 23 - 24, 2003.

		SITE
Max. possible score	**Parameter**	**BEVR 2**
20	Bottom substrate	16
20	Pool substrate char.	16
20	Pool variability	18
20	Channel alteration	15
20	Sediment deposition	16
20	Channel sinuosity	17
20	Channel flow status	17
10	Bank vegetation	7 / 7
10	Bank stability	9 / 9
10	Vegetated zone	8 / 2
170	Total	136
	Percent of maximum	**80.00**
	CONDITION*	**OPTIMAL**

* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Plafkin et al. 1989.

Table 7b. Stream and riparian habitat assessment. These Beaver Creek sites were assessed based upon criteria developed by Montana DEQ for streams with riffle prevalence. July 23 - 24, 2003.

		SITES	
Max. possible score	**Parameter**	**BEVR 1**	**BEVR 4**
10	Riffle development	6	8
10	Benthic substrate	9	7
20	Embeddedness	18	16
20	Channel alteration	18	18
20	Sediment deposition	17	16
20	Channel flow status	17	6
10	Bank stability	8 / 5	10 / 10
10	Bank vegetation	8 / 5	10 / 10
10	Vegetated zone	5 / 2	10 / 6
130	Total	101.5	99.00
	Percent of maximum	**78.08**	**76.15**
	CONDITION*	**OPTIMAL**	**SUB-OPTIMAL**

* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Plafkin et al. 1989.

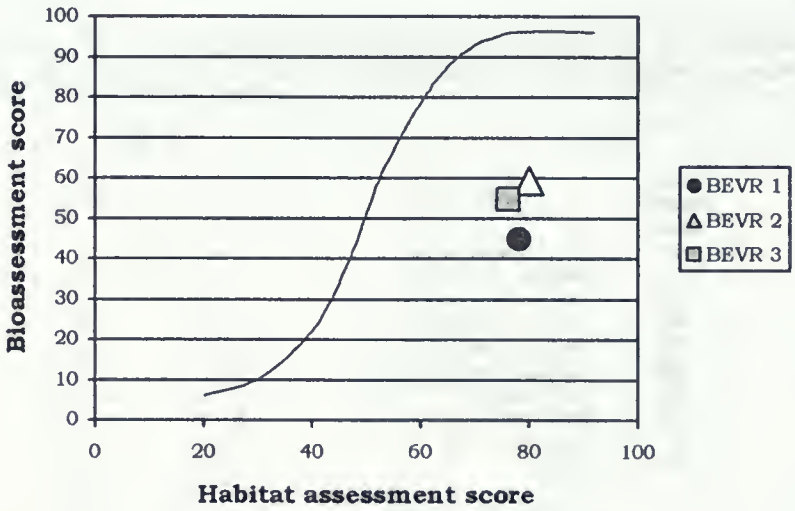
Habitat assessment vs. bioassessment

When habitat assessment scores are plotted against bioassessment scores, the resulting figure provides an opportunity to evaluate the hypothetical relationship between habitat integrity and water quality. Both factors are critical and interactive determinants of the composition and functional integrity of aquatic invertebrate assemblages. Presumably, high quality habitat, in the absence of impairments to water quality, supports functional, diverse,

and sensitive invertebrate assemblages; these are assemblages that attain high bioassessment scores. Barbour and Stribling (1991) have hypothesized that diminishing habitat quality should produce predictable diminishment of bioassessment scores, when water quality is not a further insult.

Figure 4 is a plot of habitat assessment scores against bioassessment scores for the sampled assemblages of Beaver Creek. The red line superimposed on the plot represents the hypothetical relationship between habitat quality and biotic integrity given good water quality. In this model, symbols falling in the upper right area of the graph would represent sites with high scores for both bioassessment and habitat assessment; according to this model, these would be unimpaired sites both in terms of habitat integrity as well as water quality. Some degree of habitat degradation is hypothesized for sites located along the downward progression of the red line, that is, when bioassessment scores are falling predictably with decreasing habitat scores. When habitat scores remain high, but bioassessment scores are inordinately low, sites fall into the lower right hand quadrant of the plot. According to the model, these sites support invertebrate assemblages that are impacted mostly by impairment to water quality. Symbols near the red line are sites where habitat degradation outweighs water quality perturbation in determining the integrity of biotic assemblages. The plot in Figure 3 suggests that sites on Beaver Creek suffer more from water quality degradation than from habitat disturbances.

Figure 4. Total bioassessment scores plotted against habitat assessment scores for sites on Beaver Creek. July 23 - 24, 2003. (Barbour and Stribling 1991).



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